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METHODS OF TESTING SMALL CLEAR SPECIMENS OF TIMBER
PART 1 - SAMPLING METHODS AND PHYSICAL TESTS

SRI LANKA STANDARDS INSTITUTION

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METHODS OF TESTING SMALL CLEAR SPECIMENS OF TIMBER
PART 1 - SAMPLING METHODS AND PHYSICAL TESTS

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PART 1 - SAMPLING METHODS AND PHYSICAL TESTS

FOREWORD

This Sri Lanka Standard was authorized for adoption and publication by the Council of the Sri Lanka Standards Institution on 88-11-30, after the draft, finalized by the Drafting Committee on Methods of Testing small clear specimens of timber, had been approved by the Civil Engineering Divisional Committee.

Timber is one of the oldest known construction materials and its popularity has not waned over the years in spite of competition from concrete, metals, ceramics, plastics and other building materials. Although the use of best grade naturally durable timbers is expensive due to greater demand and diminishing supply, many lesser known species are available at reasonable cost and are widely used. There is considerable scope for further studies to introduce new uses for hitherto under-utilized species, from among a multitude of species available from tropical forests, and to reduce the cost of timber structures by avoiding over design. The testing of timber is indispensable for pursuing such studies.

In evaluation of characteristics of timber, testing of small clear specimens is an important stage before the influence of defects is considered. It has, as its main purpose the provision of data for the comparison of the strength properties of different species. The test results may be also used to determine relationships between strength and properties such as density, to assist in the establishment of design functions for structural timbers, and to indicate the suitability of various timber species for specific uses. The values obtained in the determination of the properties of timber depend upon the test methods used. It is therefore desirable that these should be standardized so that results from different test centres may be correlated and more widely applied. In developing the standardized test methods given in this standard, practices adopted in other countries were reviewed and modifications were made to suit Sri Lankan conditions.

This part of the standard covers sampling methods and general requirements and deals with following physical tests : moisture content, density, radial and tangential shrinkage and swelling, volumetric shrinkage and swelling. Part 2 of this standaard deals with mechanical tests.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or measurement shall be rounded off in accordance with CS 102. The number of significant figures to be retained in the rounded off value should be the same as that of the specified value in this standard.

In the preparation of this standard the assistance derived from the publications of the International Organization for Standardization, the British Standards Institution and the Bureau of Indian Standards is gratefully acknowledged.

1 SCOPE

This part of the standard gives methods of conducting physical tests on small clear specimens of timber free from visible defects for the provision of data for the determination and comparison of properties of the different species of timber and for the determination of suitability of timber for specific end uses. It also gives sampling methods and general requirements for material intended for physical and mechanical tests.

2 SAMPLING METHODS AND GENERAL REQUIREMENTS

2.1 Selection of material

The material intended for physical and mechanical tests shall be selected taking due account of the purpose in mind (determination of the quality of stand wood, of a model tree, of a lot of sawn timber, of an individual board, etc.) as well as of the appropriate requirements for ensuring that the sample and its statistical parameters are representative of the lot. The material selected shall be in the form of logs, sawn timber and boards.

NOTE – "Stand wood" is the wood from a stand (stand is a plot of forest).

2.2 Conversion of material

2.2.1 Logs

A heart board shall be cut from a log (see Figure 1). A heart board from a log of eccentric structure shall cover the geometrical centre. From a log 180 mm or less in diameter, heart boards may be cut in the direction of two mutually perpendicular diameters (see Figure 2).

The thickness of the heart board shall be not less than 60 mm. Heart boards 40 mm thick may be cut from logs of diameter 180 mm or less. In this case, to obtain test pieces with cross-sectional dimensions greater than 30 mm, cross-sectional lengths not less than 100 mm long shall be cut from logs before sawing out heart boards.

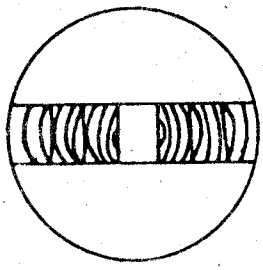

FIGURE 1 - General scheme of cutting heart board from log

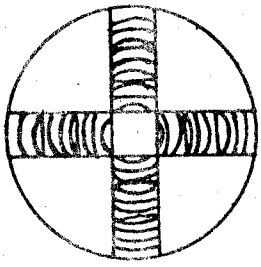

FIGURE 2 - Scheme of cutting heart board from log of diameter 180 mm or less

2.2.2 Sawn timber

The heart boards cut in accordance with **2.2.1** and selected in accordance with **2.1** shall be converted parallel to taper, into sticks 35 mm thick. The sticks containing pith shall be discarded.

The sawn timber without pith shall be converted into sticks in such a manner that at least one surface of the stick is radial or tangential.

If sawn timber of thickness 60 mm or more is converted into sticks, a portion along the grain 100 mm long shall be cut to make test pieces with cross-sectional dimensions greater than 30 mm.

2.3 Preparation of test pieces

2.3.1 Form and dimensions

One test piece for each type of test shall be cut from each stick made as specified in 2.2.2. The form and dimensions of the test pieces shall be those specified in the relevant methods of testing given in this standard.

2.3 2 Direction of grain

The grain of the wood shall be parallel to the longitudinal axis of the test pieces. The grain of the wood shall be at right angles to the longitudinal axis of the test pieces for testing perpendicular to the grain. Wherever present, growth rings on the end surfaces of test pieces shall be parallel to one pair of opposite faces and perpendicular to the other pair. Adjacent faces shall be at right angles.

2.3.3 Deviations from nominal dimensions

The permissible deviations of the gauge length of the test pieces from nominal dimensions shall not exceed ± 0.5 mm. Any value taken within the limits of permissible deviation shall be kept throughout the test piece to an accuracy of ± 0.1 mm. The dimensions of test pieces not used in calculations (for example, the length of the test piece for the static bending test) shall be kept to an accuracy of ± 1.0 mm. The working surface of the test pieces shall be clean finished.

2.3.4 The number of test pieces shall be specified taking due account of the purpose in mind (determiantion of the quality of stand wood, of a model tree, of a lot of timber, of an individual board, etc.) as well as the limit of error required at a given confidence limit.

NOTE – The limit of error is the maximum difference between the estimated value (to be made on the sample) and the true value (that would be obtained if all items of the lot were tested).

The minimum number of test pieces shall be the greater of 10 or the value of "n" given approximately by the formula :

$$n = \left[\frac{UV}{e}\right]^2$$

where,

U is the value selected for constructing the interval to get the desired confidence limit ;

V is the coefficient of variation in per cent ;

e is the limit of error expressed in per cent ; and

n shall be rounded to the nearest whole number.

The value of the main physical properties shall be determined with a limit of error 5 per cent at a confidence limit of 0.95. Hence the values for U and e are taken as 1.96 and 5 respectively.

For an aproximate determination of the minimum number of test pieces, the coefficient of variation for wood properties shown in the following table may be used.

TABLE - Coefficient of variation for wood properties

Wood property	Coefficient of variation per cent (V)
Number of growth rings in 10 mm	37
Percentage of late wood	28
Density	10
Equilibrium moisture content	5
Coefficient of linear shrinkage	28
Coefficient of volumetric shrinkage	16
Ultimate compressive strength parallel to grain	13
Ultimate strength in static bending	15
Ultimate shearing strength parallel to grain	20
Modulus of elasticity in static bending	20
Proportional limit (conventional ultimate strength) in compression perpendicular to grain	20
Ultimate tensile strength parallel to grain	20
Ultimate tensile strength perpendicular to grain	20
Impact strength in bending	32
Hardness	17

Example :
It is required to find the minimum number of test pieces needed to estimate density.

From the table, coefficient of variation V = 10. Since U = 1.96 and e = 5, by substituting in the formula :

$$n = \left[\frac{UV}{e}\right]^2$$

$$n = \left[\frac{10 \times 1.96}{5}\right]^2 = 15.366 = 16$$

Minimum number of tesst pieces required = 16

2.3.5 Conditioning

2.3.5.1 Test pieces with a standardized moisture content shall be conditioned at a temperature of 30 ± 3°C and relative humidity of 75 ± 5 per cent to bring the moisture content of the wood to that of equilibrium.

Test pieces with a moisture content equal to or above the fibre saturation point shall be produced by conversion at a moisture content at or above the fibre saturation point. Such test pieces shall be kept at a moisture content equal to or greater than the fibre saturation point. However, it is permissible to make test pieces for compression and shearing from material with a moisture content below the fibre saturation point. In this case, test pieces shall be soaked prior to testing until no further changes in dimensions are recorded.

2.3.5.2 After condtitioning, test pieces shall be stored under conditions which ensure that their moisture content remains unchanged till testing.

2.4 General requirements for physical and mechanical tests

2.4.1 Temperature and humidity conditions in the laboratory
The temperature in the laboratory where the tests are carried out shall be maintained at 30 ± 3 °C. The relative humidity should preferably be 75 ± 5 per cent. If it is not possible to maintain this relative humidity in the laboratory, test pieces shall be tested immediately after conditioning.

2.4.2 Procedure
Carry out the tests in accordance with the appropriate test method in this standard.

After the tests have been carried out, determine the moisture content and when required, the density of the test pieces. It is recommended that the moisture content be determined on samples cut from the test pieces. The minimum number of test pieces n_w used for the determination of their mean moisture content shall be at least 3 and is given by the formula :

$$n_w = n \frac{(V_w)^2}{V^2}$$

where,
n is the number of test pieces required for the determination of a wood property with coefficient of variation V (see table under 2.3.4) ; and

V_w is the coefficient of variation for the moisture content of the test pieces.

The value of n_w shall be rounded to the nearest whole number.

NOTE - 'n' is obtained using the formular given in 2.3.4 as illustrated by the example shown therein.

2.5 Calculation and expression of results
The values of the wood properties shall be calculated using the formulae given in this standard.

In treating the test results, the following shall be estimated :

a) the arithmetic mean, $\bar{x}$, from the formula :

$$\bar{x} = \frac{\Sigma x_i}{n}$$

b) the standard deviation, s, from the formula :

$$s = \sqrt{\frac{(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{\Sigma(x_i^2) - \frac{(\Sigma x_i)^2}{n}}{n-1}}$$

c) the percentage of coefficient of variation, V, from the formula :

$$V = \frac{s}{\bar{x}} \times 100$$

d) the mean error, s_r, of the arithmetic mean, from the formula :

$$s_r = \pm \frac{s}{\sqrt{n}}$$

e) the limit of error, e, at a confidence limit of 0.95 from the formula :

$$e = \frac{1.96\, s_r}{\bar{x}} \times 100$$

where

X_i is the value of an individual observation ; and

n is the number of observations.

If necessary, the test results should be adjusted to a 15 per cent moisture content. If the mean moisture content is determined from the moisture content of several test pieces, it is permissible to crrect the arithmetic mean of the test results for moisture content.

2.6 Test report
The test report of a test, specified in this standard and conducted in accordance with it, shall have the following particulars, in addition to those listed under each test :

a) reference to this standard;
b) type of test ;
c) species of wood ;
d) intended purpose of test (see 2.1) ;
e) details concerning sampling of the test pieces (number of stands selected ; number of trees selected from each stand ; number of logs selected from a sampled tree ; number of heart boards selected from a log ; number of sticks selected from a heart board ; number of test pieces selected from a stick ; number of individual sawn timber pieces selected from a lot ; number of sticks selected from an individual sawn timber piece ; number of test pieces selected from a stick etc.)

f) number of test pieces tested ;
g) date of testing ; and
h) name of organization and place of testing .

NOTE - "Stand" is a plot of forest.

3 DETERMINATION OF MOISTURE CONTENT

3.1 Principle
Determination by weighing, the loss in mass of the test piece on drying to a constant mass. Calculation of the loss in mass as a percentage of the test piece after drying.

3.2 Apparatus

3.2.1 Balance, capable of weighing up to an accuracy of 0.01 g.

3.2.2 Drying equipment, capable of drying wood to absolutely dry condition.

3.2.3 Desiccator, containing an absorbent for drying air as completely as possible.

3.3 Preparation of test pieces

3.3.1 Test pieces for determination of moisture content shall be prepared from material selected in accordance with 2.3 and made preferably in the form of right prisms having a square cross-section of side 20 mm and length along the grain of 25 ± 5 mm. After preparation, the test pieces shall be conditioned in accordance with 2.3.5, and stored under conditions which ensure that their moisture content remains unchanged.

3.3.2 It is recommended that the moisture content be determined on the test piece made for other tests or on samples cut from them. The form, dimensions and method of taking samples from test pieces as well as the minimum number of test pieces for the determination of the mean moisture content of the test pieces are specified in 2.3.

3.4 Procedure

3.4.1 Weigh the test piece (to an accuracy of 0.5 per cent of its mass in the absolutely dry condition).

3.4.2 Dry the test piece to a constant mass at a temperature of 103 ± 2°C. Constant mass is considered to be reached if the loss in mass between two successive weighings carried out at an interval of 6 hours is eqaual to or less than 0.5 per cent of the mass of the test piece.

3.4.3 Test pieces of wood species containing volatile organic substances (resins, gums, etc.) in quantities exceeding the limit of error of 5 per cent calculated as in 2.5, shall be vacuum-dried.

Presence of volatile substances can be identified during drying by odour generated in the oven.

3.4.4 After cooling the test pieces in a desiccator, weigh it repidly enough to avoid an increase in moisture content by more than 0.1 per cent. The accuracy of weighing shall be at least 0.5 per cent of the mass of the test piece.

3.5 Calculation and expression of results

The moisture content, W, of each test piece, as a percentage of mass, after drying shall be calculated to an accuracy of 1 per cent from the formula :

$$W = \frac{m_1 - m_2}{m_2} \times 100$$

where,
m_1 is the mass, in grams, of the test piece before drying ; and
m_2 is the mass, in grams, of the test piece after drying.

Calculate the arithmatic mean of the results obtained for the individual test pieces and report this as the average value for the moisture content of the test pieces.

3.6 Test report
The test report shall include the following particulars :
a) details in accordance with 2.6 ; and
b) the test results calculated as specified in **3.5** and their statistical values (see **2.5**).

4 DETERMINATION OF DENSITY

4.1 Principle
Determination of the mass of the test piece by weighing and of its volume by measurement of its dimensions or by another method. Calculation of the mass of a unit volume of the wood.

2 Apparatus

4.2.1 **Measuring instrument**, capable of determining the dimensions of the test pieces to an accuracy of 0.1 mm.

4.2.2 **Balance**, capable of weighing up to an accuracy of 0.01 g.

4.2.3 **Drying equipment**, capable of drying wood to an absolutely dry condition.

4.2.4 **Desiccator**, containing an absorbent for drying air as completely as possible.

4.3 Preparation of test pieces

4.3.1 Test pieces shall be prepared in the from of right prisms having a square cross-section of side 20 mm and length along the grain of 25 ± 5 mm. Whenever present, if growth rings are more than 4 mm wide, the dimensions of the cross-section of the test piece shall be increased to include not less than five growth rings. For the determination of the conventional density (see **4.4.3**) it is permitted to prepare the test piece of any geometrical shape, the volume of which may be easily determined.

To determine the relation between ultimate strength and density, it is recommended that the density be determined on test pieces made for particular tests or on test pieces for the determination of density, cut from them in the form of right prisms with the dimensions stated above.

4.3.2 The perparation, number of test pieces and moisture content shall be in accordance with 2.3, 2.3.4 and 2.3.5 respectively.

4.4 Procedure

4.4.1 Determination of density at the moisturer content at the time of test

Determine the mass of the tests pieces to an accuracy of 0.01 g. Measure the sides of the cross-section and the length of the test pieces along the axes of symmetry to the nearest 0.1 mm. The volume of the test pieces may be determined by another method to an accuracy of 10 mm^3. Determine the moisture content of the test pieces according to 3. Take the whole test piece as the sample for the determination of moisture content.

4.4.2 Determination of density in the absolutely dry condition

Dry the test pieces gradually to a constant mass to minimize their deformation and splitting. Carry out the weighing and measuring operations immediately after drying in accordance with 4.4.1.

4.4.3 Determination of conventional density

The moisture content of test pieces shall be greater than or equal to the fibre saturation point. The test pieces may be soaked in distilled water at room temperature until no changes in dimensions occur. Measure the dimensions or volume of the test pieces according to 4.4.1, dry the test pieces according to 4.4.2 and weigh them according to 4.4.1.

4.5 Calculation and expression of results

4.5.1 The density, ρ_W of each test piece at the moisture content, W, at the time of the test is given in kilograms per cubic metre (or grams per cubic centimetre), by the formula :

$$\rho_W = \frac{m_W}{a_W \times b_W \times l_W} = \frac{m_W}{V_W}$$

where,

m_W is the mass, in kilograms (or grams), of the test piece at moisture content W ;

a_W, b_W and l_W are the dimensions in metres (or centimetres), of the test piece at moisture content W ; and

V_W is the volume in cubic metres (or cubic centimetres), of the test piece at moisture content W.

Express the result to the nearest 5kg/m^3 (or 0.005 g/cm^3).

When required, the density ρ_w shall be adjusted to a moisture content of 15 per cent by the formula valid for moisture content from 7 per cent to 17 per cent :

$$\rho_{15} = \rho_w \left[1 - \frac{(1 - K)(W - 15)}{100} \right]$$

Where K is the coefficient of volumetric shrinkage for a change in moisture content of 1 per cent. The value of K shall be determined as specified in 6. For approximate calculations, the value of K can be taken as equal to $0.85 \times 10^{-3} \rho_w$ when the density is expressed in grams per cubic centimetre

4.5.2 The density ρ_o, of each test piece in the absolutely dry condition is given, in kilograms per cubic metre (or grams per cubic centimetre), by the formula :

$$\rho_o = \frac{m_o}{a_o \times b_o \times l_o} = \frac{m_o}{V_o}$$

where,

m_o is the mass, in kilograms (or grams), of the test piece in the absolutely dry condition ;

a_o, b_o and l_o are the dimensions, in metres (or centimetres), of the test piece in the absolutely dry condition ; and

V_o is the volume, in cubic metres (or cubic centimetres), of the test piece in the absolutely dry condition.

Express the result to the nearest 5kg/m³ (or 0.005 g/cm³).

4.5.3 The conventional density, ρ_y, of each test piece is given, in kilograms per cubic metre (or grams per cubic centimetre), by the formula :

$$\rho_Y = \frac{m_o}{a_{max} \times b_{max} \times l_{max}} = \frac{m_o}{V_{max}}$$

where,

a_{max}, b_{max} and l_{max} are the dimensions, in metres (or centimetres), of the test piece at a moisture content greater than or equal to the fibre saturation point ; and

V_{max} is the volume, in cubic metres (or cubic centimetres), at a moisture content greater than or equal to the fibre saturation point.

Express the result to the nearest 5 kg/m³ (or 0.005 g/cm³).

4.5.4 Calculate, to an accuracy of 10 kg/m³ (or 0.01 g/cm³) the arithmetic mean of the results obtained for the individual test pieces and report this as the average value for the density of the test pieces.

4.6 Test report

The test report shall include the following particulars :

a) details in accordance with **2.6** ;
b) the test results calculated as specified in **4.5** and their statistical values (see **2.5**) ; and
c) the value of coefficient k used for the adjustment of the test results to a moisture content of 15 per cent.

NOTE - Specific gravity at the appropriate condition (S_W, S_O and S_Y) can be obtained by dividing density (in Kg/m³) at the appropriate condition by 1000.

5 DETERMINATION OF RADIAL AND TANGENTIAL SHRINKAGE

5.1 Principle

Determination of linear dimensions, in the radial and tangential directions, test pieces after drying, at a moisture content in equilibrium with the normal environment, and at a moisture content equal to or greater than the fibre saturation point.

5.2 Apparatus

5.2.1 Measuring instrument, capable of determining dimensions to an accuracy of 0.01 mm, and applying a clamping force which will not cause any deformation greater than the accuracy of the instrument.

5.2.2 Oven, for drying wood at a temperature of 103 ± 2°C

5.2.3 Vessel, containing distilled water.

5.2.4 Desiccator, containing a desiccant.

5.2.5 Balance, capable of weighing up to an accuracy of 0.01 g.

5.3 Preparation of test pieces

5.3.1 Test pieces shall be made in the form of rectangular prisms, of base 20 mm x 20 mm, and of length along the grain from 10 mm to 30 mm. One side of the cross-section of the test piece shall not deviate from either the radial or the tangential direction by more than 10 degrees.

5.3.2 The preparation and number of test pieces shall be in accordance with **2.3.**

5.4 Procedure

5.4.1 The moisture content of test pieces shall be considerably higher than the fibre saturation point. When the moisture content is less than the limit of saturation, soak the test pieces in distilled water in the vessel (see **5.2.3**) at a temperature of 30 ± 3°C until no further change in dimensions occurs. Monitor the changes in dimensions every 3 days through repeated measurements of two or three test pieces in corresponding directions. Stop the soaking when the difference between two successive measurements does not exceed 0.02 mm. In this case, it should be reported that the results of the determination of shrinkage are obtained on test pieces which have been previously soaked.

5.4.2 Measure the cross-sectional dimensions of every test piece to an accuracy of 0.01 mm in the middle of the radial and tangential faces of the pieces (dimension $l_{r\ max}$ being measured in a radial direction and dimension $l_{t\ max}$ in a tangential direction).

5.4.3 Condition the test pieces to a moisture content in equilibrium with the normal environment (relative humidity 75 ± 5 per cent (also see Note at the end of this clause) temperature 30 ± 3°C) so that no checks distorting their dimensions and shape occur. Monitor the changes in dimensions of two or three control test pieces by repeated measurements, as specified in **5.4.2**, every 6 hours after stabilization of the conditioning environment. Stop the conditioning when the difference between two successive measurements does not exceed 0.02 mm. The conditioning of test pieces may be stopped by using the method of successive weighing in accordance with 3

NOTES
1) "check" is a small seperation of the wood fibres in a longitudinal direction.

2) If necessary, shrinkage may also be determined at relative humidities between 30 per cent and 90 per cent.

5.4.4 Measure the cross-sectional dimensions, l_r and l_t of every test piece, as specified in **5.4.2.**

5.4.5 Dry the test pieces to constant dimensions at a temperature of 103 ± 2°C, in the oven (see **5.2.2**) so that no checks distorting their dimensions and shape occur. Monitor the changes in dimensions of two or three control test pieces by repeated measurements, as specified in **5.4.2**, every 2 hours after 6 hours from the beginning of drying. Stop the drying when the difference between two successive measurements does not exceed 0.02 mm. The drying of test pieces may be stopped by using the method of successive weighing in accordance with **3.**

5.4.6 Test pieces in which checks occurred during the test period shall be discarded.

5.4.7 Cool the test pieces to room temperature in the desiccator.

5.4.8 Measure the cross-sectional dimensions $l_{r\,min}$ and $l_{t\,min}$ of each test piece as specified in **5.4.2.**

5.5 Calculation and expression of results

5.5.1 Calculate the total linear shrinkage, β_{max}, as a percentage, by the formulae :

a) for the radial direction :

$$\beta_{r\ max} = \frac{l_{r\ max} - l_{r\ min}}{l_{r\ max}} \times 100$$

b) for the tangential direction :

$$\beta_{t\ max} = \frac{l_{t\ max} - l_{t\ min}}{l_{t\ max}} \times 100$$

where,

$l_{r\ max}$ and $l_{t\ max}$ are the dimensions, in millimetres, of the test piece at a moisture content above the fibre saturation point, measured in the radial and tangential directions respectively ;

$l_{r\ min}$ and $l_{t\ min}$ are the dimensions, in millimetres, of the test piece after drying, measured in the radial and tangential directions respectively.

Express the results to the nearest 0.1 per cent.

5.5.2 Calculate the linear shrinkage, β_n when the moisture content changes to equilibrium with the normal environment, (relative humidity 75 ± 5 per cent ; temperature 30 ± 3°C), as a percentage, by the formulae :

a) for the radial direction :

$$\beta_{r_n} = \frac{l_{r\ max} - l_r}{l_{r\ max}} \times 100$$

b) for the tangential direction :

$$\beta_{t_n} = \frac{l_{t\ max} - l_t}{l_{t\ max}} \times 100$$

where,
l_r and l_t are the dimensions, in millimetres, of the test piece at a moisture content in equilibrium with the normal environment, measured in the radial and tangential directions respectively ;

$l_{r\ max}$ and $l_{t\ max}$ have the same meanings as in **5.5.1.**

Express the results to the nearest 0.1 per cent.

5.6 Test report
The test report shall include the following particulars :

a) details in accordance with **2.6** ;
b) the direction of the grain ;
c) the test results calculated as specified in **5.5** and their statistical values (see **2.5**) ; and
d) the relative humidity and temperature, if shrinkage was determined under conditions different from those specified in **5.4.3.**

6 DETERMINATION OF VOLUMETRIC SHRINKAGE

6.1 Principle
Determination of the change in volume of test pieces after drying, at a moisture content in equilibrium with the normal environment, and at a moisture content equal to or greater than the fibre saturation point.

6.2 Apparatus
For the determination of volumetric shrinkage, the apparatus as described in **5.2** shall be used.

6.3 Preparation of test pieces
For the determination of volumetric shrinkage, the preparation of test specimens shall be as described in **5.3.**

6.4 Procedure

6.4.1 Carry out the test in accordance with **5.4.**

6.4.2 For species showing significant shrinkage along the grain, also measure the dimensional changes of the test piece in the longitudinal direction.

NOTE - If radial and tangential shrinkage are also to be determined, then volumetric shrinkage can be obtained by measurement of $l_{a\ max}$, $l_{a\ min}$ and l_a using measurements of tests on radial and tangential shrinkage.

6.5 Calculation and expression of results

6.5.1 Calculate the volumetric shrinkage, $\beta_{V\ max}$, as a percentage, without taking into account the swelling along the grain, by the (approximate) formula :

$$\beta_{V\ max} = \frac{(l_{t\ max} \times l_{r\ max}) - (l_{t\ min} \times l_{r\ min})}{l_{t\ max} \times l_{r\ max}} \times 100$$

where,

$l_{t\ max}$ and $l_{r\ max}$ are the dimensions of the test piece, in millimetres, at a moisture content greater than the fibre saturation point, measured in the tangential and radial directions, respectively ; and

$l_{t\ min}$ and $l_{r\ min}$ are the dimensions of tlhe test piece, in millimetres, after drying, measured in the tangential and radial directions, respectively.

Express the result to the nearest 0.1 per cent.

Calculate tlhe total volumetric shrinkage, $\beta_{V\ max}$, if dimensional changes have also been measured on the test piece in the longitudinal direction. as a percentage. by the formula :

$$\beta_{V\ max} = \frac{(l_{t\ max} \times l_{r\ max} \times l_{a\ max}) - (l_{t\ min} \times l_{a\ min})}{l_{t\ max} \times l_{r\ max} \times l_{a\ max}} \times 100$$

where,

$l_{a\ max}$ is the dimension of the test piece, in millimetre, at a moisture content greater than the fibre saturation point, measured in the longitudinal directions ;

$l_{a\ min}$ is the dimension of the test piece, in millimetres, after drying, mesured in the longitudinal direction ; and

$l_{t\ max}$, $l_{r\ max}$, $l_{t\ min}$ and $l_{r\ min}$ are as defined above.

Express the result to the nearest 0.1 per cent.

6.5.2 Calculate the volumetric shrinkage, β_{vn}, when the moisture content changes to equilibrium with the normal environment (relative humidity 75 ± 5 per cent ; temperature 30 ± 3°C), as a percentage, by the (approximate) formula :

$$\beta_{V_n} = \frac{(l_{t\,max} \times l_{r\,max}) - (l_t \times l_r)}{l_{t\,max} \times l_{r\,max}} \times 100$$

where,
l_t and l_r are the dimensions of the test piece, in millimetres, at a moisture content in equilibrium with the normal environment, measured in the tangential and radial directions respectively.

$l_{t\,max}$ and $l_{r\,max}$ have the same meaning as in 6.5.1.

Express the result to the neaarest 0.1 per cent.

Calculate the volumetric shrinkage, β_{vn}, f dimensional changes have also been measured on the test piece in the longitudinal direction, as a percentage, by the formula :

$$\beta_{V_n} = \frac{(l_{t\,max} \times l_{r\,max} \times l_{a\,max}) - (l_t \times l_r \times l_a)}{l_{t\,max} \times l_{r\,max} \times l_{a\,max}} \times 100$$

where
l_a is the dimension of the test piece, in millimetres, at a moisture content in equilibrium with the normal environment, measured in the longitudinal direction.

$l_{t\,max}$, $l_{r\,max}$ and $l_{a\,max}$ have the same meaning as in 6.5.1.

Express the result to the nearest 0.1 per cent.

6.6 Test report

The test report shall include the following particulars :
a) details in accordance with 2.6.
b) the test results calculated as specified in 6.5 and their statistical values (see 2.5) ; and
c) the relative humidity and temperature, if shrinkage was determined under conditions different from those specified in 6.4.

7 DETERMINATION OF RADIAL AND TANGENTIAL SWELLING

7.1 Principle

Determination of linear dimensions, in the radial and tangential directions, of test pieces after drying, at a moisture content in equilibrium with the normal enviornment and at a moisture content equal to or greater than the fibre saturation point of wood.

7.2 Apparatus

7.2.1 Measuring instrument, capable of determining dimensions to an accuracy of 0.01 mm, fitted with parallel flat ends, each of diameter 5 mm to 8 mm, and applying a clamping force which will not cause any deformation greater than the accuracy of the instrument.

7.2.2 Oven, for drying wood at a temperature of 103 ± 2°C.

7.2.3 Vessel, containing distilled water.

7.2.4 Desiccator, containing a desiccant.

7.2.5 Balance, capable of weighing up to an accuracy of 0.01 g.

7.3 Preparation of test pieces

7.3.1 Test pieces shall be made in the form of rectangular prisms, of base 20 mm x 20 mm, and of length along the grain from 10 to 30 mm. One side of the cross-section of the test piece shall not deviate from either the radial or the tangential direction by more than 10 degrees.

7.3.2 The preparation and number of test pieces shall be in accordance with 2.

7.4 Procedure

7.4.1 Dry the test pieces to constant dimensions in the oven at a temperature of 103 ± 2°C so that no checks distorting their dimensions and shape occur. Monitor the changes in dimensions of two or three control test pieces by repeated measurements, every 2 hours after 6 hours from the beginning of drying, in corresponding directions. Stop the drying when the difference between two successive measurements does not exceed 0.02 mm. The drying of test pieces may be stoped by using the method of successive weighing in accordance with 3.4.2.

7.4.2 Cool the test pieces to room temperature in the desiccator.

7.4.3 Measure the cross-sectional dimensions of every test piece to an accuracy of 0.01 mm in the middle of the radial and tangential faces of the piece (dimension, $l_{r\ min}$, being measured in a radial direction and dimensions, $l_{t\ min}$, in a tagential direction).

7.4.4 Condition the test pieces to a moisture content in equilibrium with the normal environment (relative humidity 75 ± 5 per cent ; temperature 30 ± 3°C) so that no checks distorting their dimensions and shape occur. Monitor the changes in dimensions of two or three control test pieces by repeated measurements, as specified in **7.4.3**, every 6 hours after stabilization of the condtioning environment. Stop the conditioning when the difference between two successive measurements does not exceed 0.02 mm. The conditioning of test pieces may be stoped by using the method of successive weighing in accordancw with **3.4.2**.

NOTE - If necessary swelling may also be determined at relative humidities between 30 per cent and 90 per cent.

7.4.5 Test pieces in which checks occurred during the test period shall be discarded.

7.4.6 Measure the cross-sectional dimensions, l_r and l_t, of every test piece, as specified in **7.4.3**.

7.4.7 Submerge the test pieces in distilled water in the vessel and soak at a temperature of 30 ± 3°C until no further change in dimensions occurs. Monitor the changes in dimensions every 3 days by repeated measurements of two or three control test pieces in corresponding directions. Stop the soaking when the difference between two successive measurements does not exceed 0.02 mm.

7.4.8 Measure the cross-sectional dimensions, $l_{r\ max}$ and $l_{t\ max}$ of each test piece, as specified in **7.4.3**.

7.5 Expression of results

7.5.1 Calculate the total linear swelling, α_{max}, as a percentage, by the formulae :

a) for the radial direction

$$_{r\ max} = \frac{l_{r\ max} - l_{r\ min}}{l_{r\ min}} \times 100$$

b) for the tangential direction :

$$_{t\ max} = \frac{l_{t\ max} - l_{t\ min}}{l_{t\ min}} \times 100$$

where,
$l_{r\ min}$ and $l_{t\ min}$ are the dimensions of the test piece, in millimetres, after drying, measured in the radial and tangential directions, respectively ; and

$l_{r\ max}$ and $l_{t\ max}$ are the dimensions of the test piece, in millimetres, at a moisture content greater than the fibre saturation point of wood, measured in the radial and tangential directions, respectively

Express the results to the nearest 0.1 per cent.

7.5.2 Calculate the linear swelling, α_n, when the moisture content changes to equilibrium with the normal environment (relative humidity 75 ± 5 per cent ; temperature 30 ± 3°C) as a percentage by the formulae :

a) for the radial direction :

$$_{r_n} = \frac{l_r \times l_{r\ min}}{l_{r\ min}} \times 100$$

b) for the tangential direction :

$$_{t_n} = \frac{l_t - l_{t\ min}}{l_{t\ min}} \times 100$$

where,
l_r and l_t are the dimensions of the test piece, in millimetres, at a moisture content in equilibrium with the normal environment, measured in the radial and tangential directions, respectively.

$l_{r\,min}$ and $l_{t\,min}$ have the same meaning as in 7.5.1.

Express the results to the nearest 0.1 per cent.

7.6 Test report
The test report shall include the following particulars :

a) details in accordance with 2.6 ;
b) the direction of the grain ;
c) the test results calculated as specified as in 7.5 and their statistical values (see 2.5) ; and
d) the relative humidity and temperature, if swelling was determined under conditions different from those specified in 7.4.4.

8 DETERMINATION OF VOLUMETRIC SWELLING

8.1 Principle
Determination of the change in volume of test pieces after drying, at a moisture content in equilibrium with the normal environment, and at a moisture content equal to or greater than the fibre saturation point of wood.

8.2 Apparatus
For the determination of volumetric shrinkage, the appratus as described in 5.2 shall be used.

8.3 Preparation of test pieces
For the determination of volumetric shrinkage, the preparation of test specimens shall be done as described in 5.3.

8.4 Procedure

8.4.1 Carry out the test in accordance with 7.4.

8.4.2 For species showing significant swelling along the grain, also measure dimensional changes of the test piece in the longtitudinal direction.

8.5 Expression of results

8.5.1 Calculate the total volumetric swelling, $\alpha_{v\ max}$, as a percentage, without taking account the swelling along the grain, by the (approximate) formula :

$$\alpha_{V\ max} = \frac{(l_{t\ max} \times l_{r\ max}) - (l_{t\ min} \times l_{r\ min})}{l_{t\ min} \times l_{r\ min}} \times 100$$

where,
$l_{t\ max}$ and $l_{r\ max}$ are the dimensions of the test piece in millimetres, at a moisture contnet greater than the fibre saturation point of wood, measured in the tangential and radial directions, respectively ; and

$l_{t\ min}$ and $l_{r\ min}$ are the dimensions of the test piece, in millimetres, after drying, measured in the tangential and radial directions, respectively.

Express the result to the nearest 0.1 per cent.

Calculate the total volumetric swelling, $\alpha_{v\ max}$, if dimensional changes have been also measured on the test piece in the longitudinal direction, as a percentage, by the formula :

$$\alpha_{V\ max} = \frac{(l_{t\ max} \times l_{r\ max} \times l_{a\ max}) - (l_{t\ min} \times l_{r\ min} \times l_{a\ min})}{l_{t\ min} \times l_{r\ min} \times l_{a\ min}} \times$$

where,
$l_{a\ max}$ is the dimension of the test piece in millimetre, at a moisture content greater than the fibre saturation point of wood, measured in longitudinal direction ; and

$l_{a\ min}$ is the dimension of the test pieces, in millimetres, after drying, measured in the longitudinal direction.

Express the result to the nearest 0.1 per cent.

8.5.2 Calculate the volumetric swelling, α_{v_n}, when the moisture content changes to equilibrium with the normal environment (relative humidity 75 ± 5 per cent ; temperature 30 ± 3°C), as a percentage, by the (approximate) formula :

$$V_n = \frac{(l_t \times l_r) - (l_{t\,min} \times l_{r\,min})}{l_{t\,min} \times l_{r\,min}} \times 100$$

where,
l_t and l_r are the dimensions of the test piece, in millimetrers, at a moisture content in equilibrium with the normal environment, measured in the tangential and radial directions, respectively

$l_{t\,min}$ and $l_{r\,min}$ have the same meaning as in 8.5.1.

Express the result to the nearest 0.1 per cent.

Calculate the total volumetric swelling α_{v_n}, if dimentional changes have been also measured on the test piece in the longitudinal direction, as a percentage, by the formula :

$$\alpha_{V_n} = \frac{(l_t \times l_r \times l_a) - (l_{t\,min} \times l_{r\,min} \times l_{a\,min})}{l_{t\,min} \times l_{r\,min} \times l_{a\,min}}$$

where
l_a is the dimension of the test piece, in millimetres, at a moisture content in equilibrium with the normal environment, measured in the longitudinal direction :

$l_{t\,min}$, $l_{r\,min}$ and $l_{a\,min}$ have the same meaning as in 8.5.1.

Express the result to the nearest 0.1 per cent.

8.6 Test report
The test report shall include the following particulars :

a) details in accordance with 2.6
b) the test results calculated as specified in 8.5 and their statistcal values (see 2.5) ; and
c) the relative humidity and temperature, if swelling was determined under conditions different from those specified in 8.4.